

CLAIMS

1. A modified surface wherein the adhesion or attachment of particles to the modified surface has been minimised or prevented by adjusting the Lifshitz-van der Waals (LW) surface free energy of an unmodified surface to be equal to or approximately equal to the Lifshitz-van der Waals (LW) surface free energy of particles in an environment surrounding the surface when the modified surface is in use.

2. A modified surface according to claim 1 wherein the particles are foulants.

3. A modified surface according to claim 1 wherein the particles are selected from any of the following: cells, proteins, prions, bacteria, amino acids, nucleic acids, metallic based compounds, organometallics, organic compounds, inorganic compounds or any other type of discrete separate particles.

4. A modified surface according to any preceding claim wherein there is a surface with a Lifshitz-van der Waals (LW) surface free energy of $\gamma_{\text{surface}}^{\text{LW}}$ on which the adhesion or attachment of particles is minimised or prevented by modifying the surface free energy $\gamma_{\text{surface}}^{\text{LW}}$ of the surface in accordance with the Lifshitz-van der Waals (LW) surface free energy of the particles so that:

$$\gamma_{\text{surface}}^{\text{LW}} \cong \gamma_{\text{S,Min}}^{\text{LW}}$$

wherein $\gamma_{\text{S,min}}^{\text{LW}}$ is the minimum level of attachment to a surface S and is defined as follows:

$$\sqrt{\gamma_{\text{S,Min}}^{\text{LW}}} = (1/2)(\sqrt{\gamma_{\text{particles}}^{\text{LW}}} + \sqrt{\gamma_{\text{environment}}^{\text{LW}}})$$

where $\gamma_{\text{particles}}^{\text{LW}}$ is the LW surface free energy of particles, and $\gamma_{\text{environment}}^{\text{LW}}$ is the LW surface free energy of an environment when the modified surface is in use.

5 5. A modified surface according to any preceding claim wherein the surface is one which comes into contact with cells and/or proteins and/or prions within a living human or animal body.

10 6. A modified surface according to claim 5 wherein there is a surface with a Lifshitz-van der Waals (LW) surface free energy of $\gamma_{\text{surface}}^{\text{LW}}$ on which the adhesion or attachment of cells and/or proteins and/or prions is minimised or prevented by modifying the surface free
15 energy $\gamma_{\text{surface}}^{\text{LW}}$ of the surface in accordance with the Lifshitz-van der Waals (LW) surface free energy of the cells and/or proteins and/or prions so that:

$$\gamma_{\text{surface}}^{\text{LW}} \cong \gamma_{S, \text{Min}}^{\text{LW}}$$

20 wherein $\gamma_{S, \text{min}}^{\text{LW}}$ is the minimum level of attachment to a surface S and is defined as follows:

$$\sqrt{\gamma_{S, \text{Min}}^{\text{LW}}} = (1/2)(\sqrt{\gamma_{\text{cells and/or proteins and/or prions}}^{\text{LW}}} + \sqrt{\gamma_{\text{solution and/or whole blood}}^{\text{LW}}})$$

where $\gamma_{\text{cells and/or proteins and/or prions}}^{\text{LW}}$ is the LW surface free energy of cells and/or proteins and/or prions, and $\gamma_{\text{solution and/or whole blood}}^{\text{LW}}$ is the LW surface free energy of a
25 solution and/or of whole blood when the modified surface is in use.

30 7. A modified surface according to any preceding claim wherein the surface is modified with a coating of modified diamond-like carbon (DLC), Ag-PTFE-surfactant or Ni-Cu-P-PTFE wherein the coated surface inhibits

bacterial adhesion and/or colonisation, thrombus adhesion to the surface and/or foulant formation (i.e. particle formation) such as prion, blood protein and/or other protein.

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8. A modified surface according to claim 7 wherein the diamond-like carbon (DLC) is modified by incorporating elements selected from any of the following: halogens such as fluorine, chlorine and bromine; Group IV elements such as silicon and germanium; Group V elements such as nitrogen and phosphorous; Group VI elements such as oxygen and sulphur; and transition metals such as titanium, tantalum, tungsten and niobium.

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9. A modified surface according to claim 8 wherein the elements are present in an amount of about 0-40% by weight.

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10. A modified surface according to any of claims 8 or 9 wherein the elements are incorporated into the diamond-like carbon by co-sputtering.

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11. A modified surface according to any of claims 8 or 9 wherein the elements are incorporated into the diamond-like carbon (DLC) using reactive gases such as fluorinous monomers (e.g. C_2F_2 , C_2F_4 and HCF_3), silicon organic monomers (e.g. $Si(CH_3)_4$) gaseous hydrocarbons (eg. C_2H_2) and gases such as O_2 and N_2 .

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12. A modified surface according to claim 7 wherein the modified diamond-like carbon (DLC) is deposited using any of the following methods: microwave plasma deposition, plasma-enhanced vapour deposition, plasma-induced cold deposition, magnetron sputtering and ion beam-assisted deposition.

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13. A modified surface according to claim 7 wherein the surfactant in the Ag-PTFE-surfactant is non-ionic, anionic or cationic.

5 14. A modified surface according to any of claims 7 or 13 wherein the ratio of Ag:PTFE:surfactant is about 80-60%:10-39%:1-10% by weight.

10 15. A modified surface according to any of claims 7 to 13 wherein the ratio of Ag:PTFE:surfactant is about 75%:22%:3% by weight.

15 16. A modified surface according to any of claims 7 or 13 and 14 wherein the surfactant in the Ag-PTFE-surfactant is selected from any of the following: $C_{20}H_{20}F_{23}N_2O_4I$, and polyoxyethylene nonylphenyl ether.

20 17. A modified surface according to claim 16 wherein the polyoxyethylene nonylphenyl ether may be selected from any of the following: 4-(C_9H_{19}) $C_6H_4(OCH_2CH_2)_nOH$, $n \approx 12$,
Hydrophile Lipophile Balance (HLB)=12;; 4-
(C_9H_{19}) $C_6H_4(OCH_2CH_2)_nOH$, $n \approx 40$, HLB=17.8; 4-
(C_9H_{19}) $C_6H_4(OCH_2CH_2)_nOH$, $n \approx 100$, HLB=19; and
(C_9H_{19}) $_2C_6H_3(OCH_2CH_2)_nOH$, $n \approx 150$, HLB=19.

25 18. A modified surface according to any of claims 7 or 13 to 17 wherein the Ag-PTFE-surfactant coating is obtained using an electroless plating technique.

30 19. A modified surface according to any of claims 7 or 13 to 17 wherein the Ag-PTFE-surfactant coating is obtained using an electroplating technique.

20. A modified surface according to claim 7 wherein the Ni-Cu-P-PTFE coating is obtained using an electroless plating technique.

5 21. A modified surface according to claim 7 wherein the Ni-Cu-P-PTFE coating is obtained using an electroplating technique.

10 22. A modified surface according to any of claims 7 or 20 to 21 wherein the ratio of Ni:Cu:P:PTFE is about 97-40%:1-20%:1-20%:1-20% by weight.

15 23. A modified surface according to any of claims 7 or 20 to 21 wherein the Ni:Cu:P:PTFE ratio is about 80%:11%:4%:5% by weight.

20 24. A modified surface according to any preceding claim wherein the surface which is coated is selected from any of the following: healthcare products; dental care products; baby care products; personal hygiene products; consumer cleaning and disinfectant products; institutional and industrial cleaning products; food preparation devices and packaging; water storage products; water treatment products; water delivery
25 systems; biofilm sensitive systems; and laboratory and scientific equipment.

30 25. A modified surface according to any preceding claim wherein the modified surface is part of a medical device.

35 26. A modified surface according to claim 25 wherein the medical device is selected from any of the following: endoscopes and accessories; ophthalmic equipment; dental equipment; surgical instruments; heart valves; stents; catheters; joint prostheses; intraocular lenses, dental implants, electrodes and cable equipment.

27. A modified surface according to any preceding claim wherein the modified surface inhibits the following bacteria: *Staphylococcus epidermidis*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Escherichia coli*, *Candida albicans* or any other microorganisms which could cause device-related infections.

28. A method for preventing or minimising the adhesion or attachment of particles to a surface by modifying the surface to form a modified surface so that the Lifshitz-van der Waals (LW) surface free energy of the modified surface is equal to or approximately equal to the Lifshitz-van-der Waals (LW) surface free energy of particles in an environment surrounding the surface.

29. A device comprising a modified surface according to any of claims 1 to 27.

30. A method of modifying a surface wherein the surface is modified so that the adhesion or attachment of particles to the modified surface has been minimised or prevented by adjusting the Lifshitz-van der Waals (LW) surface free energy of an unmodified surface to be equal to or approximately equal to the Lifshitz-van der Waals (LW) surface free energy of particles in an environment surrounding the surface when the modified surface is in use.

31. Use of a device comprising a modified surface according to any of claims 1 to 27 wherein the modified surface prevents or minimises the attachment of particles to the modified surface.